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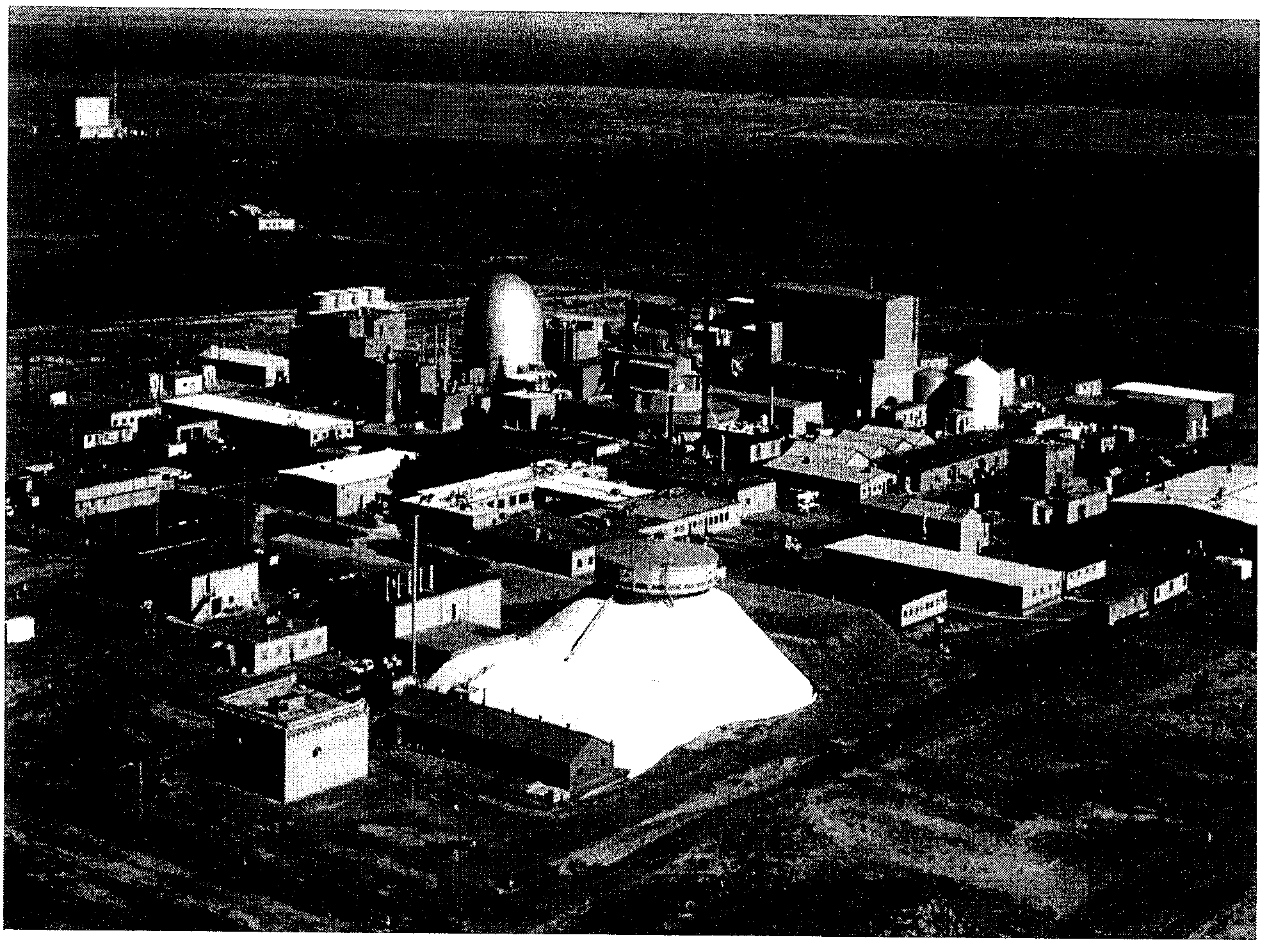
INEEL
IDAHO NATIONAL ENGINEERING & ENVIRONMENTAL LABORATORY

IDAHO DEPARTMENT OF HEALTH AND WELFARE

DIVISION OF ENVIRONMENTAL QUALITY

Final Remedial Design

Argonne National Laboratory - West



Operable Unit 9-04
Idaho National Engineering and Environmental Laboratory
Idaho Falls, Idaho

Final Remedial Design
Argonne National Laboratory - West

October 26, 1999

Prepared by:

The Department of Energy
The Idaho Department of Health and Welfare-Division of Environmental Quality
and
the Environmental Protection Agency-Region 10

Operable Unit 9-04
Idaho National Engineering and Environmental Laboratory
Idaho Falls, Idaho

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Abstract

This comprehensive remedial design/remedial action work plan for Waste Area Group 9, Operable Unit 9-04, was developed to implement the selected and contingent alternative as stated in the *Final Record of Decision for the Argonne National Laboratory-West*. During the comprehensive remedial investigation/feasibility study, it was determined that eight sites contain unacceptable risks to human or ecological receptors if no remedial action is implemented. These eight sites are the Industrial Waste Pond, Ditch A, Ditch B, Main Cooling Tower Blowdown Ditch, Sewage Lagoons, Interceptor Canal-Canal, Interceptor Canal-Mound, and the Industrial Waste Lift Station Discharge Ditch. The December 8, 1998, Remedial Design/Remedial Action Scope of Work for Waste Area Group 9 document describes the working schedule for remedial activities and strategy for remedial design. This Remedial Design report describes (in detail) the specifications for implementing the selected and contingent remedial action at these eight sites.

The selected remediation alternative was phytoremediation for all eight waste sites. The implementation of phytoremediation was contingent on successful bench-scale testing that was conducted in 1998. The results of the bench-scale tests are summarized in this document and show that phytoremediation of the cesium-contaminated soil can be successfully completed within the time outlined in the October 8, 1997, Feasibility Study. However, the bench-scale tests on the inorganic removal was lower than anticipated and cleanup would take longer than what was estimated in the feasibility study. Each of the sites that had inorganic contaminants that posed unacceptable risks to the ecological receptors were evaluated to determine the number of years needed to reach the remediation goals. If the phytoremediation time required to reach the remediation goals was greater than 10 years, the contingent remedy of soil excavation with on-INEEL disposal was selected. This contingent excavation with on-INEEL disposal is proposed for two areas at ANL-W—Ditch B and the east portion of the Main Cooling Tower Blowdown Ditch. Both of these sites had concentrations of chromium that were sufficiently high that phytoremediation would take much longer than 10 years.

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ACRONYMS

ANL-W	Argonne National Laboratory - West
ARARs	Applicable or Relevant and Appropriate Requirements
BBWI	Bectel, Babcox and Wilcox, Incorporated
BLS	Below Land Surface
BTU	British Thermal Unit
CFA	Central Facilities Area
CFR	Code of Federal Regulations
COC	Contaminant of Concern
COCA	Consent Order and Compliance Agreement
COPC	Contaminant of Potential Concern
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
DOE	Department of Energy
DOE-ARG	Department of Energy-Argonne Group
DOE-CH	Department of Energy-Chicago Operations Office
DOE-ID	Department of Energy-Idaho Operations Office
EPA	Environmental Protection Agency - Region 10
ERA	Ecological Risk Assessment
EBR-II	Experimental Breeder Reactor II
FS	Feasibility Study
FFA/CO	Federal Facility Agreement and Consent Order
FCF	Fuel Conditioning Facility
HASP	Health and Safety Plan
Hqs	Hazard Quotients

HFEF/S	Hot Fuel Examination Facility South
HWMA	Hazardous Waste Management Act
ICP	Institutional Control Plan
IDAPA	Idaho Administrative Procedures Act
IDHW	Idaho Department of Health and Welfare
IFR	Integral Fast Reactor
INEEL	Idaho National Engineering and Environmental Laboratory
LMITCO	Lockheed Martin Idaho Technologies Company
MSL	Mean Sea Level
NOAA	National Oceanic and Atmospheric Administration
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NPL	National Priorities List
O&M	Operations and Maintenance
OSHA	Occupational Safety and Health Act
OU	Operable Unit
PCBs	Polycholorinated Biphenyls
PPE	Personnel Protection Agency
RAOs	Remedial action Objectives
RGs	Remediation Goals
RME	Reasonable Maximum Exposure
ROD	Record of Decision
RI	Remedial Investigation
RCRA	Resource Conservation and Recovery Act
RWMC	Radioactive Waste Management Complex
SRP	Snake River Plain

SRPA	Snake River Plain Aquifer
SPF	Sodium Process Facility
TBC	To Be Considered
TREAT	Transient Reactor Test Facility
UCL	Upper Confidence Limit
UMTRA	Uranium Mill Tailings Remedial Action
USDA	United States Department of Agriculture
WAG 9	Waste Area Group 9
WERF	Waste Experimental Reduction Facility
ZPPR	Zero Power Physics Reactor

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Waste Area Group 9
Draft Remedial Design

1 INTRODUCTION

1.1 INEEL Background

The Idaho National Engineering and Environmental Laboratory (INEEL) is a government facility managed by the U.S. Department of Energy (DOE), located 32 miles (51 km) west of Idaho Falls, Idaho, and occupies 890 square miles (2,305 km^2) of the northeastern portion of the Eastern Snake River Plain. Argonne National Laboratory-West (ANL-W) is located in the southeastern portion of the INEEL, as shown in Figure 1-1. To better manage environmental investigations, the INEEL was subdivided into 10 Waste Area Groups (WAGs). Identified contaminant release sites in each WAG were in turn divided into operable units (OUs) to expedite the investigations and any required remedial actions. Waste Area Group 9 covers ANL-W and contains four OUs that were investigated for contaminant releases to the environment. Within these four OUs, 37 known or suspected contaminant release sites have been identified. Two of the identified 37 release sites have been further subdivided into smaller areas based on their waste discharges and physical modeling parameter variations within a release site. Thus, the term "site" will herein refer to a named release site in one of the OUs. While "area" will herein be used to define all or a portion of an identified OU release site. In addition to the 37 release sites, ANL-W has also investigated two sites from WAG 10 that are within a mile of the facility and may have co-located risks.

The INEEL lands are within the aboriginal land area of the Shoshone-Bannock Tribes. The Tribes have used the land and waters within and surrounding the INEEL for fishing, hunting, plant gathering, medicinal, religious, ceremonial, and other cultural uses since time immemorial. These lands and waters provided the Tribes their home and sustained their way of life. The record of the Tribes' aboriginal presence at the INEEL is considerable, and DOE has documented an excess of 1,500 prehistoric and historic archeological sites at the INEEL.

Facilities at the INEEL are primarily dedicated to nuclear research, development, and waste management. Surrounding areas are managed by the Bureau of Land Management for multipurpose use. The developed area within the INEEL is surrounded by a 500-square-mile (1,295 km^2) buffer zone used for cattle and sheep grazing. Communities nearest to ANL-W are Atomic City (southwest), Arco (west), Butte City (west), Howe (northwest), Mud Lake (northeast), and Terreton (northeast). The land surrounding the INEEL is approximately 45% agricultural, 45% open, and 10% urban. Sheep, cattle, hogs, poultry, and dairy cattle are produced; and potatoes, alfalfa, sugar beets, wheat, barley, oats, canola, sunflower, forage, and seed crops are cultivated. Most of the land surrounding the INEEL is owned by private individuals or the U.S. Government, as shown in Figure 1-2.

Public access to the INEEL is strictly controlled by fences and security personnel. State Highways 22, 28, and 33 cross the northeastern portion of the INEEL and U.S. Highways 20 and 26 cross the southern portion approximately 20 miles (32.2 km) and 5 miles (8 km) away from ANL-W, respectively. A total of 90 miles (145 km) of paved highways pass through the INEEL and are used by the general public.

The Snake River Plain Aquifer (SRPA), the largest potable aquifer in Idaho, underlies the Eastern Snake River Plain and INEEL. The aquifer is approximately 200 miles (322 km) long, 20 to 60 miles (32.2 to 96.5 km) wide, and covers an area of approximately 9,600 square miles (24,853 km^2). The depth to the SRPA varies from approximately 200 feet (61 m) in the northeastern corner of the INEEL to approximately 900 feet (274 m) in the southeastern corner. This change in groundwater depth in the northeastern corner to the southeastern corner occurs over a horizontal distance of 42 miles (67.6 km). Depth to groundwater is approximately 640 feet (195 m) below ANL-W and the groundwater flow direction is south-southwest. Drinking water for employees at ANL-W is obtained from two production wells located in the west-central portion of the ANL-W facility.

Most INEEL facilities are currently operated by one of three Government contractors: a consortium of Bechtel, Babcox and Wilcox Incorporated (BBWI), Bechtel, and Argonne National Laboratory-West (ANL-W). All conduct various programs at the INEEL under the supervision of three DOE offices: DOE-Idaho (DOE-ID), Department of Defense-Pittsburgh Naval Reactors Office, and DOE-Chicago (DOE-CH), repsectively.

1.2 ANL-W Background

ANL-W, a prime operating contractor to DOE-CH, began a redirected nuclear research and development program in FY 1995. The redirected program involves research to help solve near-term high-priority missions, including the treatment of DOE spent nuclear fuel and reactor decontamination and decommissioning technologies. ANL-W is also currently in the process of conducting shutdown and termination activities for the Experimental Breeder Reactor II (EBR-II). Within the ANL-W site are a number of research and support facilities that contribute to the total volume of waste generated at ANL-W. These facilities currently generate radioactive low-level waste, radioactive transuranic waste, hazardous waste, mixed waste, sanitary waste, and industrial waste. Approximately 750 people are employed at the ANL-W facility.

ANL-W was established in the mid 1950s and is located approximately 30 miles west of Idaho Falls. ANL-W houses extensive support facilities for three major nuclear reactors: the Transient Reactor Test Facility (TREAT), EBR-II, and the Zero Power Physics Reactor (ZPPR).

The first reactor to operate at the ANL-W site was TREAT, which was built in 1959. As its name implies, TREAT was designed for overpower transient tests of fuel. Its driver fuel, consisting of finely divided uranium oxide in a graphite matrix, has a high heat capacity that enables it to withstand tests in which experimental fuel may be melted. Used extensively at first for safety tests of water-reactor fuels, TREAT is now used mainly for safety tests for various fuel types as well as for nonreactor experiments. It has periodically undergone modifications as part of the TREAT upgrade project.

EBR-II, a 62.5 megawatt thermal reactor, went into operation in 1964 capable of producing 19.5-megawatts of electrical power in the liquid-metal reactor power plant. It is a pool-type sodium-cooled reactor, designed to operate with metallic fuel. It was provided with its own Fuel Cycle Facility (FCF), adjacent to the reactor building, for remote pyrometallurgical reprocessing and refabrification of reactor fuel. The Fuel Cycle Facility provided five complete core loadings of recycled fuel for EBR-II.

Over the years, the mission of EBR-II was redirected from that of a power-plant demonstration (with integral fuel cycle) to that of an irradiation test facility for mixed uranium-plutonium

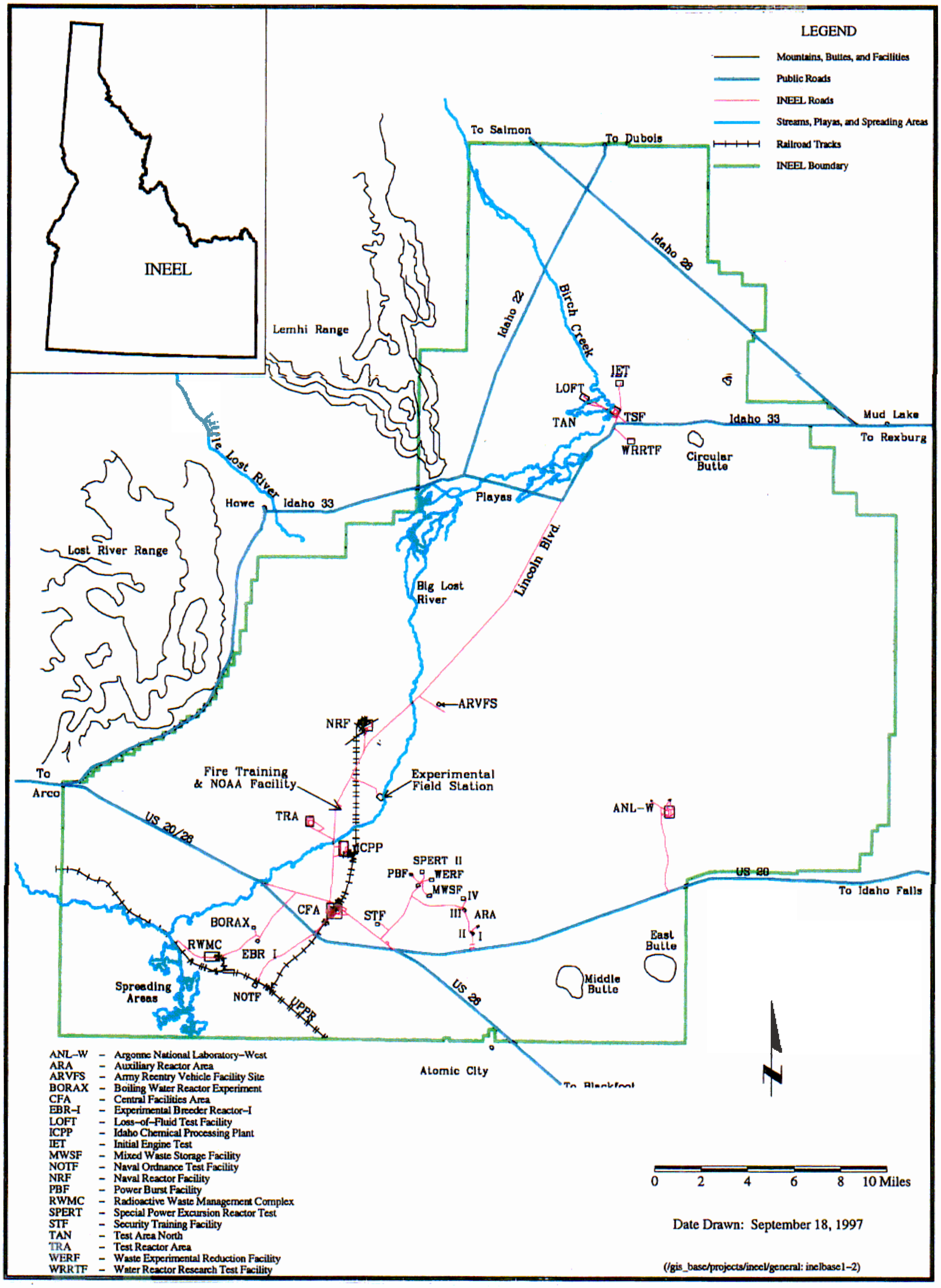

Figure 1-1. Location of the INEEL and Major Facilities with Respect to the State of Idaho.

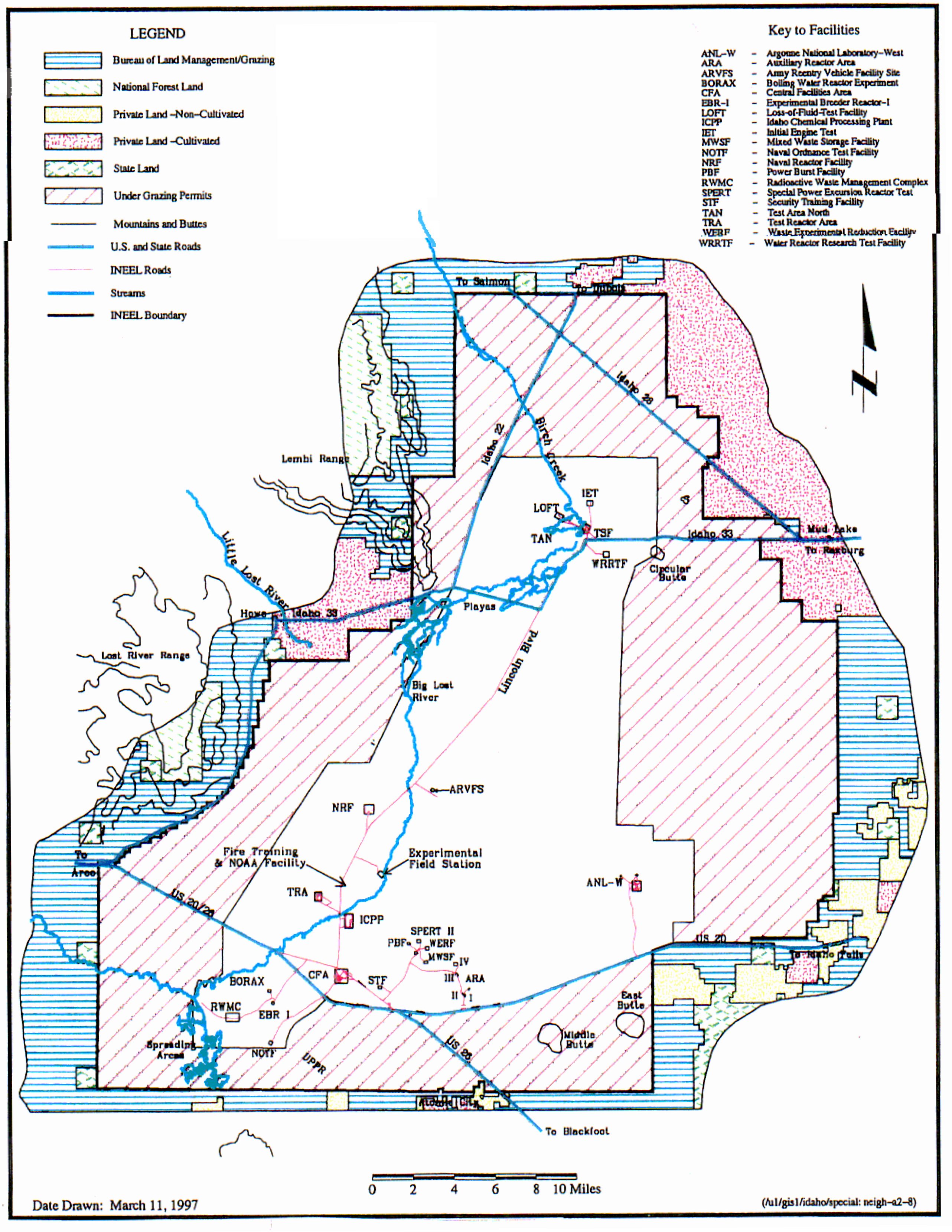

Figure 1-2. Ownership of Lands Surrounding the INEEL.

fuels for future liquid-metal reactors. The pyrometallurgical process used in the Fuel Cycle Facility was not suitable for ceramic fuels so the facility was converted to the Hot Fuel Examination Facility South (HFEF/S).

EBR-II continued to be fueled with metallic uranium driver fuel for operating convenience. This fuel was gradually improved to greatly increase its burnup, thus contributing to a high plant factor for irradiation tests. Over the years of operation, much valuable operating experience has been gained on sodium systems, including the removal and maintenance of primary sodium pumps and other components. In the 1970s, the mission of EBR-II was again shifted in emphasis; this time to the Operational Reliability Testing Program. This program was aimed at studying the milder, but more probable types of fuel and reactor malfunctions that could lead to accident sequence. In addition to preventing accidents, its aim was to better define the operating limits and tolerable faults in reactor operation, thus leading to both safer and more economical plants. The components of this EBR-II program included tests of fuel to and beyond cladding breach, loss-of-coolant flow tests, mild power transients, and studies of man-machine interfaces.

In the early 1980s, ANL-W reexamined the basic design of liquid-metal-cooled fast reactors. The results of this study led to the Integral-Fast-Reactor (IFR) concept. The IFR incorporated four basic elements: sodium cooling; a pool configuration; a compact, integral fuel cycle facility; and a ternary metal alloy fuel. Modifications to EBR-II and HFEF/S have been made to support the pyroprocessing and fuel manufacturing for the IFR demonstration project. Since 1994, ANL-W has been conducting shutdown and termination activities for the EBR-II. These shutdown activities include defueling EBR-II and draining the primary and secondary sodium loops and placing the reactor in a radiologically safe shutdown condition. The Fuel Cycle Facility has been converted to the Fuel Conditioning Facility. The mission of the Fuel Conditioning Facility is to electrochemically treat EBR-II fuel to create radioactive waste forms that are acceptable for disposal in a national geologic repository.

ZPPR was put into operation at ANL-W in 1969. ZPPR is large enough to enable core-physics studies of full-scale breeder reactors that will produce up to 1,000 megawatts. ZPPR has also been used for mockups of metallic cores and space-reactor cores. ZPPR was placed in programmatic standby in fiscal year 1989.

Various chemical and radioactive wastes were generated from these three reactors and the support facilities at ANL-W. Operation of these facilities and the corresponding waste streams have been evaluated and documented in the Facility Assessment and Screening document of 1973. This document, which is based on process knowledge, has been used as an initial starting point for ANL-W cleanup activities.

1.3 Identification of Release Sites

Potential release sites identified at ANL-W facilities in the Federal Facility Agreement and Consent Order (FFA/CO) include wastewater structures and leaching ponds, underground storage tanks, rubble piles, cooling towers, an injection well, french drains, and assorted spills. Possible contaminants at the various ANL-W sites include primarily petroleum products, acids, bases, PCBs, radionuclides, and heavy metals. These are the chemical and radioactive wastes generated from scientific and engineering research at ANL-W.

1.4 Enforcement Activities

In July 1989, the Environmental Protection Agency proposed listing the INEEL on the National Priorities List (NPL) of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). The Environmental Protection Agency (EPA) issued a final ruling that listed the INEEL as an NPL site in November 1989. The FFA/CO was developed to establish the procedural framework and schedule for developing, prioritizing, implementing, and monitoring response actions at the INEEL in accordance with CERCLA, the Resource Conservation and Recovery Act (RCRA), and Idaho Hazardous Waste Management Act. DOE, the EPA and Idaho Department of Health and Welfare (IDHW) have determined that hazardous waste release sites at ANL-W would be remediated through the CERCLA process, as defined in the FFA/CO, which superseded the existing RCRA-driven Consent Order and Compliance Agreement (COCA) requirements. The FFA/CO identified 4 OUs, consisting of 19 sites within Waste Area Group 9 that required additional activities under the CERCLA process. An additional 18 sites were determined to need no further action at the time the FFA/CO was signed. Thus, a total of 37 WAG 9 sites were evaluated during the OU 9-04 Comprehensive RI/FS process and the results are summarized in this ROD.

One unit in OU 9-04 [Main Cooling Tower Blowdown Ditch (ANL-01A)] was originally included as a Land Disposal Unit under COCA on the basis that corrosive liquid wastes were discharged after 1980. DOE, along with the EPA and IDHW WAG 9 managers, have determined that the Main Cooling Tower Blowdown Ditch is a RCRA Land Disposal Unit and will be remediated under the CERCLA process in accordance with the applicable substantive requirements of RCRA/Hazardous Waste Management Act (HWMA), if there is an unacceptable risk to human health or the environment. However, the FFA/CO has only adopted RCRA corrective action [3004 (u) & (v)], and not RCRA/HWMA closure. Therefore, upon completion of the remedial action, DOE must receive approval from the IDHW Department of Environmental Quality director that the Main Cooling Tower Blowdown Ditch has been closed pursuant to RCRA/HWMA closure requirements.

The OU 9-04 comprehensive RI/FS conducted ANL-W resulted in the identification of eight areas with potential risk to human health and/or the environment that would require some type of remedial action (W7500-000-ES-02, October 1997). The Proposed Plan (January 1998) identified the agencies' preferred alternative for the eight areas of concern at ANL-W.

1.5 ROD Summary

The Record of Decision (ROD) for WAG 9 was signed on September 29, 1998, and identifies that eight areas will undergo remediation until the Remediation Goals (RGs) are met. To meet the RGs, DOE has identified a selected remedy of phytoremediation and a contingent remedy of excavation and disposal. The initial and long-term use of the phytoremediation as the remedy depends on the success of the bench- and field-scale tests, respectively. If phytoremediation is not working on a contaminant or site, the contingent remedy of excavation and disposal can be initiated after concensouse has been reached between the DOE, EPA, and IDHW/DEQ . DOE has determined that the contingent remedy will be initiated for two sites at ANL-W in 1999. DOE is currently preparing an Explaination of Significant Difference (ESD) prior to the implementation of the contingent remedy . A brief summary of the selected phytoremediation and contingent excavation and disposal remedies is included in Sections 1.5.1 and 1.5.2, respectively.

Investigation of the 37 WAG 9 sites at ANL-W and the 2 WAG 10 sites near ANL-W resulted in identification of eight areas that would require some sort of action to be protective of human health and the environment. Of these eight areas, the ANL-09 Interceptor Canal-Canal contained cesium 137 that will naturally decay to acceptable levels within the next 100-years. This site only requires controls to make sure that the DOE 100 year institutional controls are still in place and are protective. Thus, only seven areas are retained for remedial activities.

The seven areas that are targeted to undergo remedial activities in accordance with the WAG 9 ROD signed on September 29, 1998, are shown in Figure 1-3. Two of these seven will not undergo remedial activities until their useful life is completed —the Sanitary Sewage Lagoons (ANL-04) and the Industrial Waste Pond (ANL-01). The Sanitary Sewage Lagoons are scheduled for remediation in approximately 2033 and the Industrial Waste Pond starting in approximately 2003. Both of these sites contain contaminants in their sludges that are unacceptable to the small burrowing ecological receptors. The delay in remedial activities does not pose any unacceptable risks since these areas will continue to accept discharge water and the sludges are underwater, which eliminates the exposure pathway to the burrowing animals. Remedial activities will be initiated on these two areas when their useful life is complete and if the new sample results exceed latest soil screening levels for human and ecological receptors for the viable exposure pathways. Continued releases over time may change the concentrations of the known contaminants in these areas and/or soil screening levels will change over time with new risk assessment data being evaluated and incorporated.

1.5.1 Description of Selected Remedy

The selected remedy for these sites; Industrial Waste Pond and associated Ditches (ANL-01), Main Cooling Tower Blowdown Ditch (ANL-01A), Sanitary Sewage Lagoons (ANL-04), Interceptor Canal (ANL-09), and the Industrial Waste Lift Station Discharge Ditch (ANL-35) — is phytoremediation. Phytoremediation is the generic term for "phytoextraction" an innovative/emerging technology that utilizes plants to extract the contaminants from the soil. Phytoremediation would be conducted insitu to remove the metals and the radionuclides from the soils via normal uptake mechanisms of the plants. The plant vegetation is then harvested, sampled, and shipped to an incinerator for volume reduction. The resultant ash will then be sampled and sent to a permitted disposal facility. Phytoremediation would not be initiated on the Sanitary Sewage Lagoons (ANL-04) until approximately 2033, when the ANL-W facility is scheduled for closure. The start of the phytoremediation for the Industrial Waste Pond (ANL-01) will not be initiated until successful demonstration of phytoremediation at the other ANL-W sites and the cooling water discharges from the Sodium Processing Facility (SPF) are completed. The final SPF cooling water discharges are planned for 2003. This delay in phytoremediation startup for either site dose not pose any increase in the risks to human health and/or the environment.

The effectiveness and technical implementability of phytoremediation are very site-specific. DOE estimates that six growing seasons would be required to meet the established Remedial Action Objectives (RAOs). This estimate assumes natural decay of cesium-137, along with a 5% annual uptake by plants. Sample results of the ANL-W site show that contaminants are predominantly bound in the upper foot of soils. Thus, most of the contaminants are already within the plant root zone and no major movement of soil is necessary. The plants would require additional irrigation and soil amendments. The

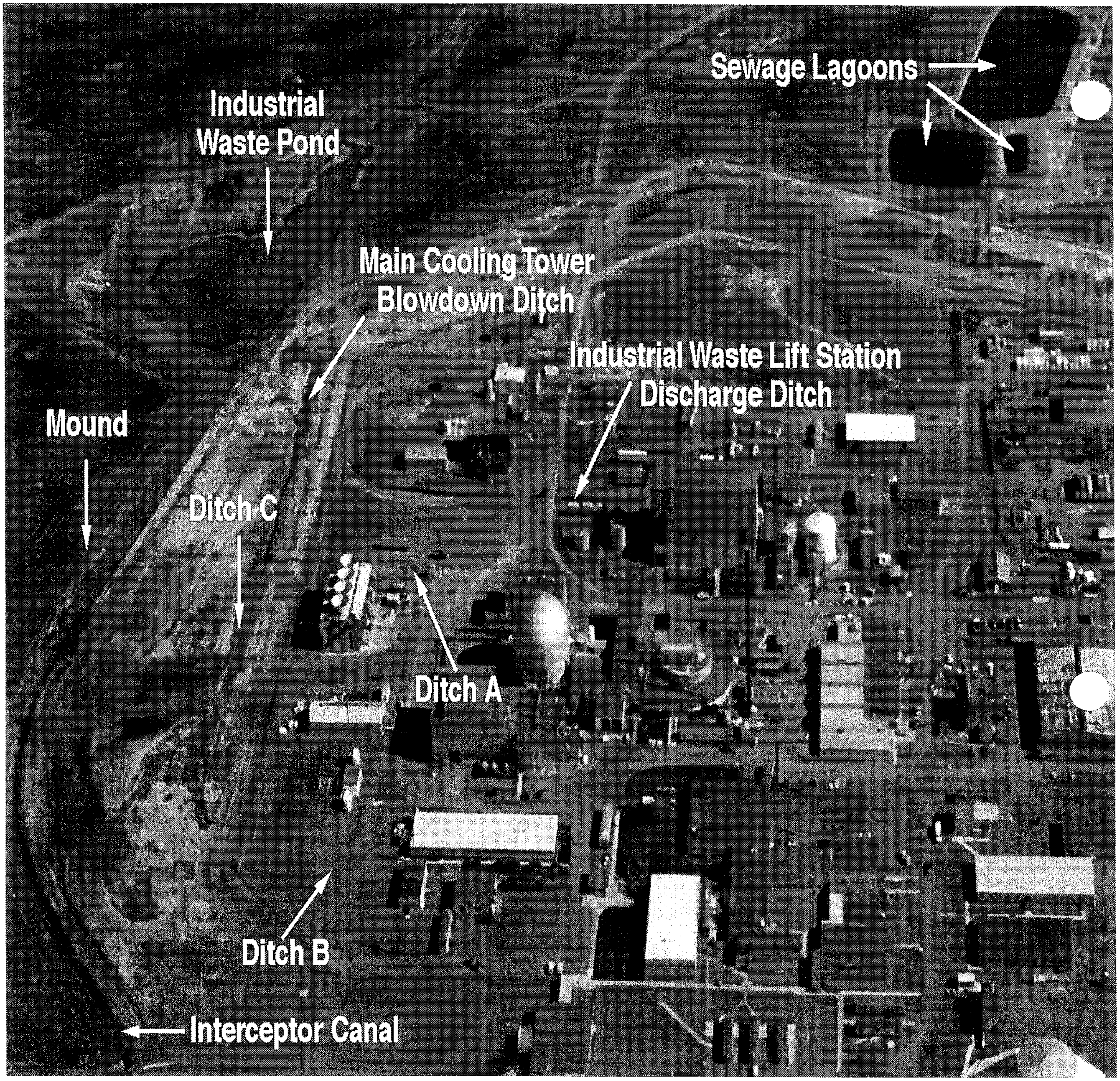

Figure 1-3. Location of the Argonne National Laboratory-West Sites that Require Remediation.

plant stalks, along with the wetted soil condition, would help control the spread of windblown contaminants. DOE conducted a bench-scale testing of soils in 1998 to determine applicability of this remedial alternative. DOE has tested nonnative INEEL plant species for their applicability for phytoremediation. Where nonnative weedy plants are grown, they will be harvested before they go to seed.

It is anticipated that phytoremediation will remove contaminants to acceptable levels after six field seasons. These acceptable levels are defined by the RAOs for contaminated soils at ANL-W. Phytoremediation will eliminate the need for long-term monitoring and maintenance activities, surface water diversions, land use and access restrictions after 100 years, and long-term environmental monitoring (air, sediment, and groundwater). The major components of the selected remedy for ANL-W are:

- Completion of the phytoremediation workplan for field-scale testing.
- Conducting a field-scale phytoremediation test of selected plant species at the sites that pose unacceptable risks.
- Determining the effectiveness and implementability of phytoremediation based on results of field-scale testing.
- Collecting soil and plant samples after a two-year field season to be used to determine the effectiveness of phytoremediation on ANL-W soils.
- Harvesting, compacting, incinerating, and disposing of the above- and below-ground plant matter that will be sent to a permitted landfill.
- Continuing the planting/harvesting process for phytoremediation only if completion of the two-year field-scale testing is successful. (This process would continue until RAOs are attained.)
- Installing access restrictions, consisting of fences, bird netting, and posting warning signs.
- Reviewing the remedy no less than every five years from the signature of the ROD until the year 2098
- Implementing DOE controls that limit residential land use for at least 100 years from now (2098).

1.5.2 Description of Contingent Remedy

If it is determined that the selected remedy of phytoremediation does not adequately reduce the principle risks to human health and the environment after completion of the two-year field season, a contingent alternative of excavation and disposal has been selected. The contingent remedy of excavation and disposal would be used to remove contaminated soils from the Industrial Waste Pond and associated Ditches A, and B (ANL-01); Main Cooling Tower Blowdown Ditch (ANL-01A); Sanitary Sewage Lagoons (ANL-04); Interceptor Canal-Mound and Interceptor Canal-Canal (ANL-09); and the Industrial Waste Lift Station Discharge Ditch (ANL-35). The on-INEEL disposal location for these contaminated soils could consist of a yet to be built Soils Repository at the Idaho Chemical Processing Plant or the Radioactive Waste Management Complex (RWMC). The final on-INEEL location would be determined during the Remedial Design/Remedial Action phase for WAG 9. Excavation and disposal activities would not be initiated on the Sanitary Sewage Lagoons (ANL-04) until approximately 2035 when ANL-W is scheduled for closure. The start of the phytoremediation for the Industrial Waste Pond (ANL-01) will not be initiated until the cooling water discharges from the SPF are completed. The final SPF cooling water discharges are planned for 2003. This delay in excavation and disposal startup for either site dose not pose any increase in the risks to human health and/or the environment. The major components of the contingent remedy for ANL-W are:

- Contaminants in the waste areas are currently planed for on-INEEL disposal at either the RWMC or INEEL Soils Repository, depending on radiation levels in the soil. Final location of soils will be documented in the ESD.

- Verification sampling would be used to validate that the remaining soil concentrations are below the RAOs.

- Review of the remedy no less than every five years from the ROD signature until the year 2098.

- Implementation of DOE controls that limit residential land use for at least 100 years from now (2098).

The no action alternative is reaffirmed and selected as the appropriate alternative for the remaining 33 areas at ANL-W. These 33 areas have risks that are at acceptable levels based on the information gathered during the remedial investigation.

The possibility exists that contaminated environmental media (not identified by the INEEL FFA/CO or in this comprehensive investigation) will be discovered in the future as a result of routine operations, maintenance activities, and decontamination and dismantlement activities at ANL-W. Upon discovery of a new contaminant source by DOE, IDHW, or the EPA, that contaminant source will be evaluated and appropriate response action taken in accordance with the FFA/CO.

1.6 Scope of Draft Remedial Design

This draft Remedial Design Work Plan summarizes the information necessary to perform the two-year field-scale phytoremediation at ANL-W as specified in the WAG 9 ROD. The draft RD will be written in enough detail that the EPA and IDHW WAG managers, DOE officials, and ANL-W employees and subcontractors can use it as a recipe for the two-year field-scale phytoremediation test at ANL-W. Implementation of the phytoremediation work to be performed by subcontractors or ANL-W employees will be documented in the form of standard operating procedures. Once this RD document is final any changes that are necessary to perform the phytoremediation activities will be made by updating and revising the standard operating procedures. This will allow ANL-W the flexibility to tailor various activities to the actual site conditions as they change without revising and resubmitting the RD to the WAG managers. The objectives of this RD are to:

- Determine each of the sites that will be remediated, the pre-planting, planting, harvesting, and disposal activities that will be conducted. Each site will be designed on an individual basis because watering requirements, nutrient requirements, and type and depth of plants will need to be individualized for each of the sites to be remediated.

- Perform sample collection of the plants during phytoremediation to determine the uptake percent per crop for the plants.

- Perform real-time visualization mapping before and while the plants are growing.

- Perform soil-verification sampling after the two-year field study to determine the effectiveness of phytoremediation.

- Install biobarriers for the ecological receptors where necessary.

- Develop equipment and procedures necessary to safely package and transport plant matter to other DOE facilities for volume reduction from incineration and ash solidification and disposal.

- Prepare an interim Remedial Action report that documents the effectiveness of the phytoremediation two-year field test.

At the completion of the two-year field test for phytoremediation, decision will be made by WAG 9 managers on whether or not continued phytoremediation should occur. The decision will be based on verification results documented in the interim RA report. It is possible that a hybridization of the selected and contingent remedy will be implemented for the individual sites after the interim RA report is submitted. This hybridization between phytoremediation and excavation and disposal would be based on the success and failure of phytoremediation of specific contaminants at the various sites. The final decision of phytoremediation and/or excavation and disposal will have to be a mutually-agreeable decision between DOE, the EPA, and IDHW/DEQ.

1.7 Report Organization

This RD Report has been written to serve two purposes. The first purpose is to fulfill a regulatory deliverable to the EPA and IDHW WAG as part of the FFA/CO agreement. The second is to provide all the necessary information that a contractor would need in order to complete the remedial activities. To facilitate using this document for these two purposes, the document has been written in a "cookbook" fashinon (thatt is to say it is a recipe for completing the phytoremediation activities at ANL-W while still fulfilling the FFA/CO requirements).

Section 1 provides a brief history of what has happened to date in the cleanup of the WAG 9 site, and a brief description of the organization of this document.

Section 2 provides a brief summary of the physical setting of ANL-W, along with key information needed for successful phytoremediation.

Section 3 provides a summary of the Bench-scale phytoremediation results for both the cesium and inorganically-contaminated soils that were conducted in the summer of 1998.

Sections 4 through 9 provide the "recipes" for performing phytoremediation at the ANL-01 Ditch A, ANL-01 Ditch B, ANL-01A Main Cooling Tower Blowdown Ditch, ANL-09 Interceptor Canal, ANL-35 Industrial Waste Lift Station Discharge Ditch, and ANL-01 Industrial Waste Pond site, respectively. Each section discusses the preplanting, planting, harvesting, and disposal activities necessary, as well as any special conditions at each site. Each of these sections was written as a stand-alone document to complete the necessary work.

Section 10 provides remedial project information (such as cost estimates, schedules, and FFA/CO deliverables). Current cost plans for performing the phytoremediation remedy are based on original estimates that have been refined for changing conditions and actual known costs.

A number of appendices are included as part of this Remedial Design Report. Some of these appendices include stand-alone documents (such as the Health and Safety Plan) that are necessary to the phytoremediation effort yet would make this Remedial Design Report too cumbersome to read. While others include large pull-out maps or other detailed information that is not easily digested while reading this Report. Appendix A includes maps of each of the sites that show the plan and profile of the site, along with irrigation system and the irrigation spray pattern. Appendix B includes the Operations and Maintenance Plan that discusses how sites that will not be remediated to levels that would allow unrestricted use will be maintained to prevent the exposure pathway to the receptors. Appendix C provides the Quality Assurance Project Plan for phytoremediation. Appendix D contains the phytoremediation Health and Safety Plan for performing the phytoremediation activities. Air modeling results are shown in Appendix E. Appendix F contains the working schedule for phytoremediation and excavation work that will be performed at the site in 1999. Appendix G includes the equipment and parts lists for each site that will be used for phytoremediation and finally, Appendix H contains the Instituational Control Plan for WAG 9. Each of these appendices will have to be routinely updated to incorporate changes in; EPA and/or IDHW regulations, ANL-W work procedures, and/or site conditions.

2 PHYSICAL AND HYDROGEOLOGIC SETTING

2.1 Physical INEEL Site Description

The INEEL site occupies approximately 890 square miles (2,300 km^2) of the northwestern portion of the eastern Snake River Plain (SRP) in southeast Idaho. The INEEL site is nearly 39 miles (63 km) long from north to south and about 36 miles wide (east-west) in its broadest southern portion. The INEEL includes portions of five Idaho counties (Bingham, Bonneville, Butte, Clark, and Jefferson) and lies within Townships 2 to 8 N and Ranges 28 to 34 E, Boise baseline and meridian. Figure 2-1 shows the location of the INEEL with respect to the counties, State, and major rivers and mountain ranges.

The surface of the INEEL is a relatively flat, semiarid, sagebrush desert, with predominant relief being manifested either as volcanic buttes jutting up from the desert floor or as unevenly surfaced basalt flows or flow vents and fissures. Elevations on the INEEL range from 5,200 ft in the northeast to 4,750 ft in the central lowlands, with an average elevation of 4,975 ft.

Characteristics of the uppermost water-bearing units beneath ANL-W, plus regional and local physiographic, meteorologic, ecologic, geologic, and hydrologic settings of the ANL-W facilities are summarized in the following sections. This information is necessary for incorporation into this document because of it's importance to growing plants on ANL-W soils. This information was in the WAG 9-04 Comprehensive Work Plan and (where appropriate) has been updated with the latest information available to support remedial alternatives in the ROD. Specific details about each of the sites being remediated will be described in further detail in following chapters. This chapter only provides general background information relative to all sites requiring remediation.

2.1.1 Physiographic and Geomorphic Setting

ANL-W is in the southeastern portion of the INEEL and is roughly rectangular-shaped administrative area encompassing approximately 890 acres. ANL-W facilities are within a local topographically closed-basin. The surface gradually from south to north, at approximately 30 ft per mile. Maximum topographic relief within the ANL-W administrative boundary is about 50 ft, ranging from 5110 ft above mean sea level on the north boundary, to 5160 ft on a basalt ridge to the southeast.

The Twin Buttes are the most prominent topographic features within the INEEL and are located southwest of ANL-W. East and Middle Twin Buttes rise 1100 and 800 feet, respectively, above the plain. Big Southern Butte, a composite acidic volcanic dome several miles south of the INEEL, is the most prominent single feature on the entire plain, rising approximately 2500 feet above the level of the plain.

2.1.2 Meteorology

The U. S. Weather Bureau established a monitoring station at the Central Facilities Area (CFA) in 1949. A 250-foot tower is also located just outside the east security fence surrounding ANL-W, however, this tower has not been in continuous operation for as long as the CFA station.

2.1.2.1 Air Temperature

Data has been collected from both 2 and 10 meters above the ground surface at ANL-W. The two-meter data set is limited in time from August 1993 to the present. The record presented is considered typical of temperature conditions in the vicinity of ANL-W. Although there is a much longer record available from the CFA station, the distance of ANL-W from that station precludes its use. Therefore, this data is presented here in that it more accurately portrays surface conditions at ANL-W. The maximum average monthly temperature during the time of record was 84.8°F in July. The minimum average monthly temperature of 7.9°F was recorded in December. Table 2-1 shows monthly mean, maximum, and minimum temperatures for the time of record at ANL-W. ANL-W anticipates that the growing season will begin in April if seeds are sown the previous fall. The growing season will last until mid October and allow harvesting activities to be completed before winter.

Table 2-1 Monthly Temperatures (8/93-7/95)

Month[a]	Mean[b]	Maximum[b]	Minimum[b]
January	22.5	31.6	12.9
February	25.1	36.7	13.8
March	35.1	48.4	22.1
April	42.9	56.2	27.8
May	52.1	65.2	37.1
June	59.3	73.7	41.0
July	67.2	84.8	46.5
August	65.3	83.3	44.7
September	57.0	75.7	36.2
October	41.8	56.6	27.5
November	22.7	35.4	8.9
December	19.8	29.0	7.9

[a] Time period August 1993 to July 1995.
[b] All values in degrees Farenhiet.

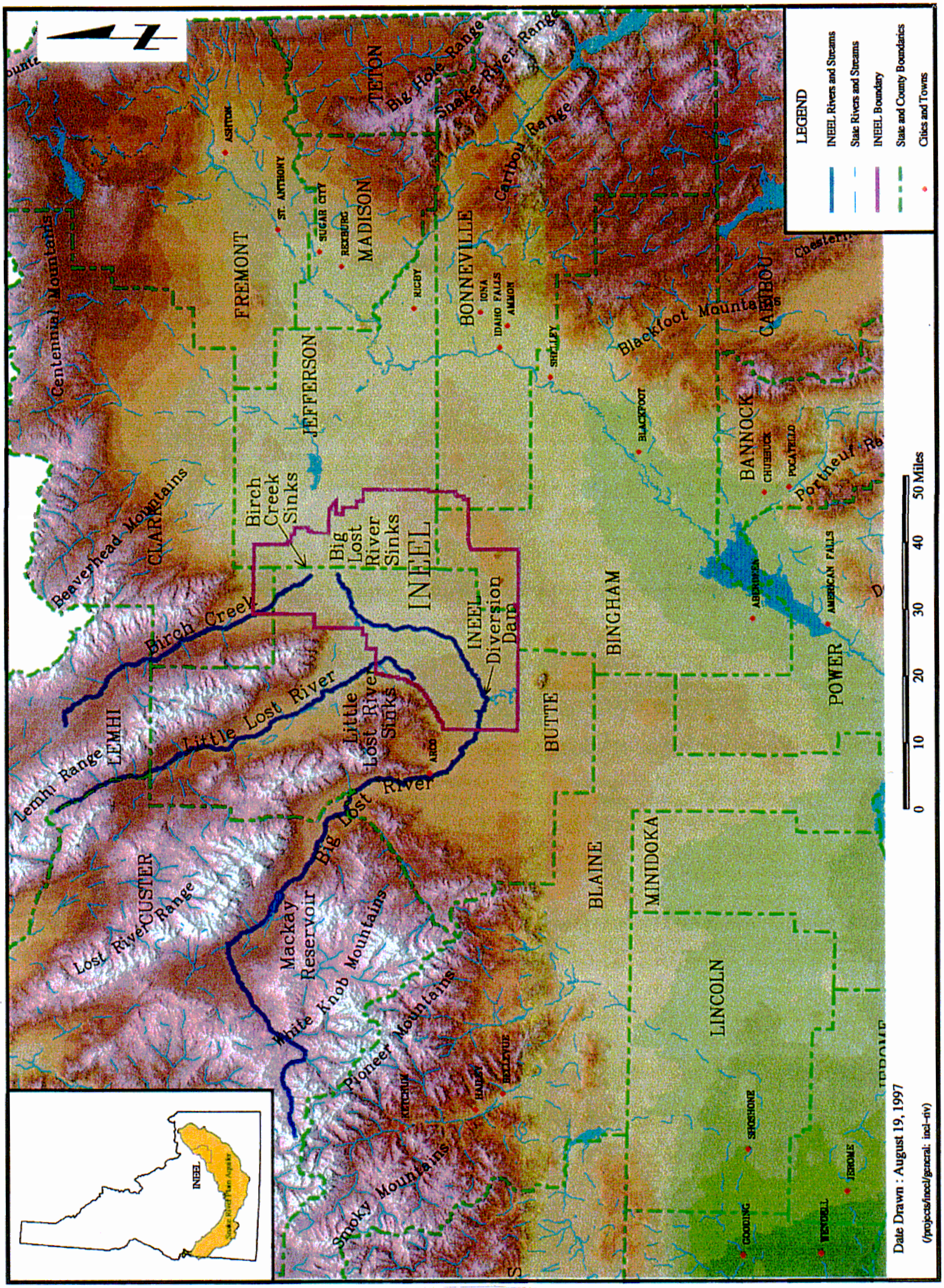

Figure 2-1 Location of INEEL Counties, Rivers and Mountain Ranges

2.1.2.2 Precipitation

Precipitation and humidity are not measured at the ANL-W tower. However, the National Oceanic and Atmospheric Administration (NOAA) did an evaluation and is of the opinion that the use of CFA data for these parameters is reasonable. Precipitation was measured as rainfall and snowfall for the period January 1950 to December 1988. During this period, most of the precipitation was received in May and June and averaged 1.2 in. The annual total average was 8.71 in. As could be expected, most snowfall occurred during December and January. The monthly average snowfall event for December and January was 6.4 in. and 6.1 in., respectively. Wet-bulb temperature humidity measurements from CFA run from 1956 to 1961. The highest average occurred in the winter at 55%; a low average of 18% was recorded in the summer. In order to optimize the plant removals, ANL-W will need to supply additional irrigation. This irrigation will allow the plants to attain larger biomass; additionally, semisaturated condition will allow for better contaminant uptake.

2.1.2.3 Evaporation and Infiltration

Although NOAA does not measure pan evaporation at the INEEL, adjusted Class-A values have been made through regression analysis of other southeast Idaho sites. Data from 1950-51, 1958-59, 1963-64, and 1969-70 yielded an adjusted range of 40 to 46 in. per year. Other estimates for the INEEL have values of 36 in. per year from saturated ground, 32 to 36 in. per year from shallow lakes, and six to nine in. per year from native vegetation. The plants used for phytoremediation will be optimally spaced and exceed the water requirement of six to nine in. per year for native plants. The water evapotranspiration rates will be different for the different plants at ANL-W.

Evaporation rates (calculated from the drop in level of the Industrial Waste Pond during 1995) yield values between 0.43 in./day and 0.10 in./day for summer and winter, respectively. Infiltration is calculated by using the hydrologic equation and solving for the infiltration term. This yields values for the Industrial Waste Pond of between 0.36 in./day to 0.07 in./day for summer and winter, respectively.

2.1.2.4 Wind

Wind measurements at ANL-W are made at 10 meters and 250 ft above the ground surface. From this data, ANL-W is clearly subject to the same southwest and northeast winds as the rest of the INEEL. Winds tend to be diurnal, with up slope winds (those out of the southeast) occurring during the day and down slope winds (those out of the northeast) occurring at night. During the five-year time of record at ANL-W from 1990 to 1994, winds blew from the southeast 14% of the time, from the south-southeast 11% of the time, and from the northeast 10% of the time. Winds were calm during only 2.49% of the time on record. An annual total wind rose for the period 1990 to 1994 is shown in Figure 2-2.

2.1.2.5 Special Phenomena

A thunderstorm is defined by the National Weather Service as time during which thunder is heard at a given station. According to the definition, lightning, rain and/or hail are not required during this time. Following this strict definition, the ANL-W may experience two to three thunderstorms from June to August. Thunderstorms have been observed during each month of the year, but only rarely from November to February. Thunderstorms on the INEEL tend to be less severe than in the surrounding mountains because of the high cloud base. In many instances, precipitation from a storm will evaporate before reaching the ground. Individual storms may, however, occasionally exceed long-term average rain amounts for a storm.

Local thunderstorms may also be accompanied by micro bursts, which can produce dust storms and occasional wind damage. Thunderstorms may also be accompanied by both cloud-to-ground and cloud-to-cloud lightning.

Because there are no permanent, natural, surface water features near ANL-W flooding is not a major concern. The facility has been inundated in the past by rapid snow-melt events. To control this, a diversion dam was constructed south of the facility. This dam has a gate that, when closed, diverts water into the adjacent drainage and from there directly into the Industrial Waste Pond.

The areas that will be remediated using phytoremediation consist of either soil on a ditch bank on soil in the bottom of drainage ditches and infiltration ponds. ANL-W will grade these areas to allow for storm water runoff. During some storms, ponding of water is likely to occur in the drainage ditches because of the drainage restrictions from plants. Ponding of the water is anticipated to last from one hour up to two days and will have little effect on plants. The plants in the ditches will reduce the velocity of water flowing and will reduce the volume of water reaching the Industrial Waste Pond.

2.1.3 Soils

Soil samples have been collected in and around ANL-W to support specific investigations. Most recently, soil samples for agronomic analysis have been collected for the 1998 greenhouse study on cesium removal from the Interceptor Canal-Mound soils and inorganic removal of the Main Cooling Tower Blowdown Ditch soils.

2.1.3.1 Soil Type

The ANL-W site is located on an alluvial plain of the Big Lost River. The thickness of the surficial sediment in the vicinity of the ANL-W site is shown in Figure 2-3. Depths range from outcroppings at the surface to depths of 4.2 m (14 ft). In general, the depths of surface soils above the basalt tend to increase from approximately 60 cm (2 ft) on the east side of the area to a depth of 4.2 m (14 ft) near the west side of the security fence.

The general soil types for ANL-W are shown in Figure 2-4. The two types of soils shown are 425-Bondfarm-Rock outcrop-Grassy Butte complex and 432-Malm-Bondfarm-Matheson complex. As shown in the figure, the soil type 425-Bondfarm-Rock outcrop-Grassy Butte complex is found over all the sites in OU 9-04. This soil consists of 40% Bondfarm loamy sand, 30% rock outcrop, and 20% Grassy Butte loamy sand. The Bondfarm soil is on the concave and convex side slopes and is surrounded by areas of the Grassy Butte soils, rock outcrop is in the areas of slightly higher than areas of Bondfarm soils, and the Grassy Butte soil is in hummocky areas. Also included in this complex are about 10% Matheson loamy sand, a soil that is similar to the Grassy butte soils but that is less than 40 in. deep to bedrock, and Terreton loamy sand. The Bondfarm soil is shallow and well drained. It formed in eolian material. Typically, the surface layer is light brownish-gray loamy sand about 10 cm (4 in.) thick. The subsoil and substratum are very pale-brown sandy loam 35 cm (14 in.) thick. Basalt is at a depth of 45 cm (18 in.). The soil is calcareous throughout and has a layer of lime accumulation at a depth of 4 in. The permeability of the soil is

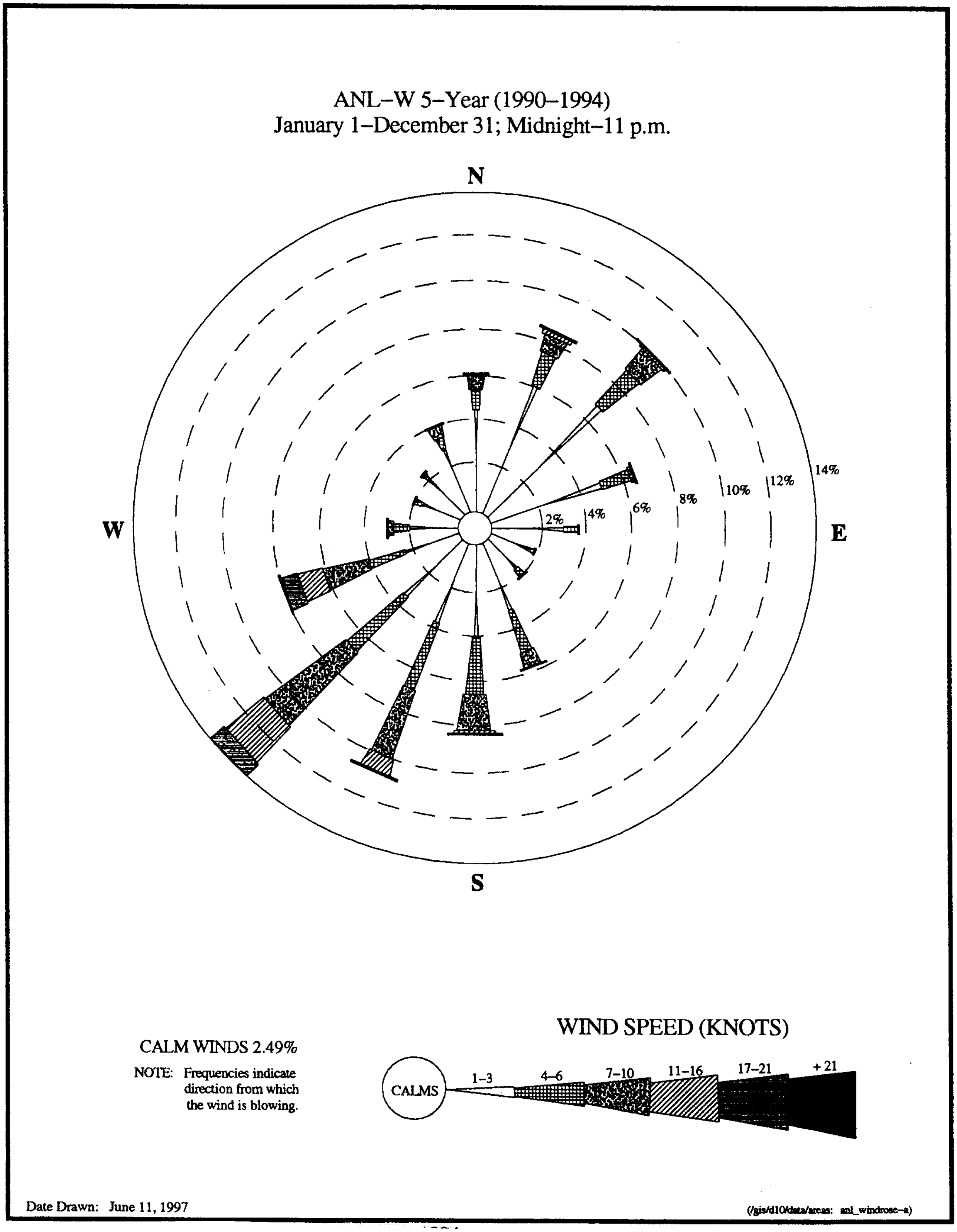

Figure 2-2 ANL-W 5 Year Wind Rose 1990-1994

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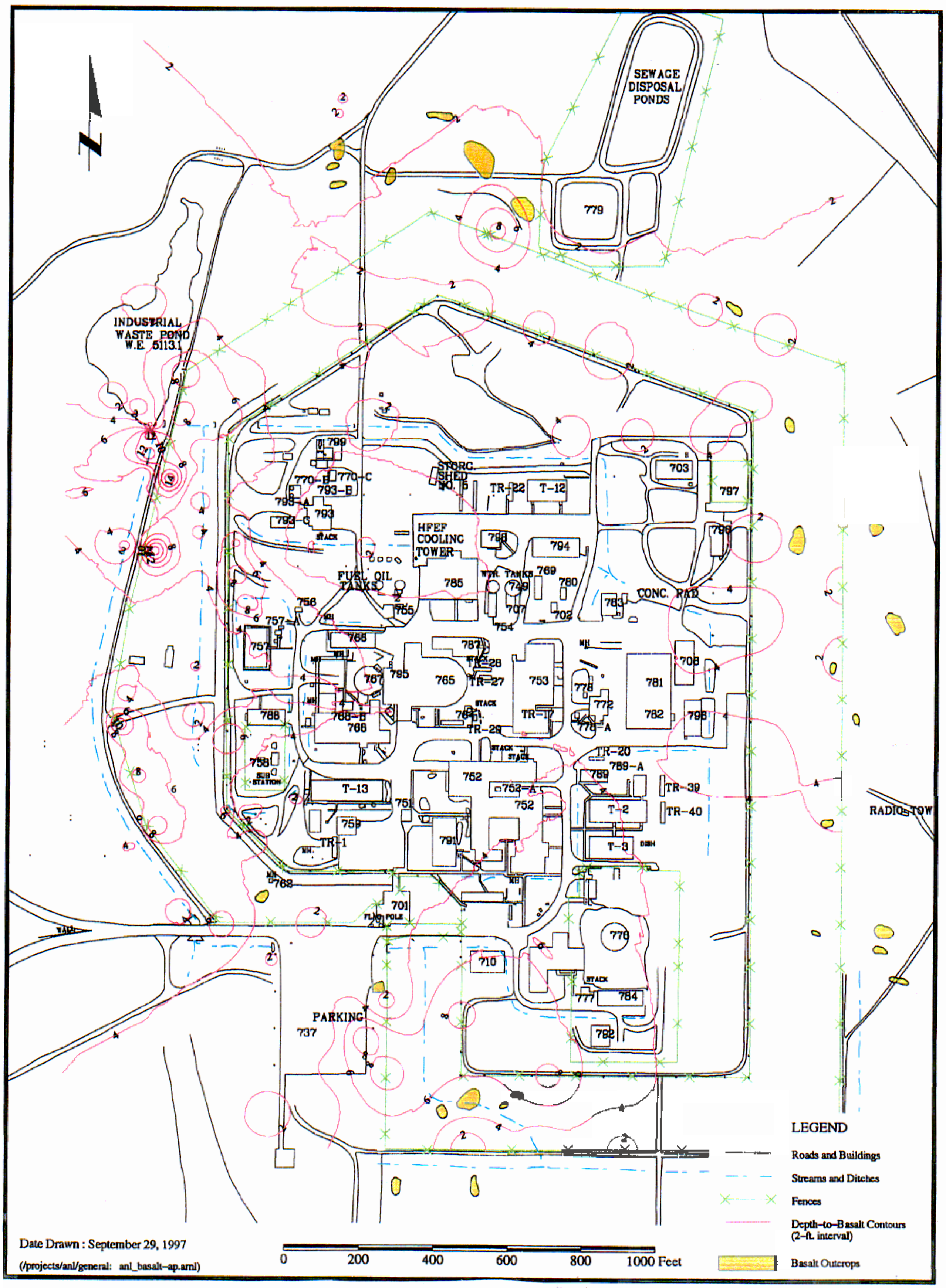

Figure 2-3 Thickness of Surficial Material above Basalt

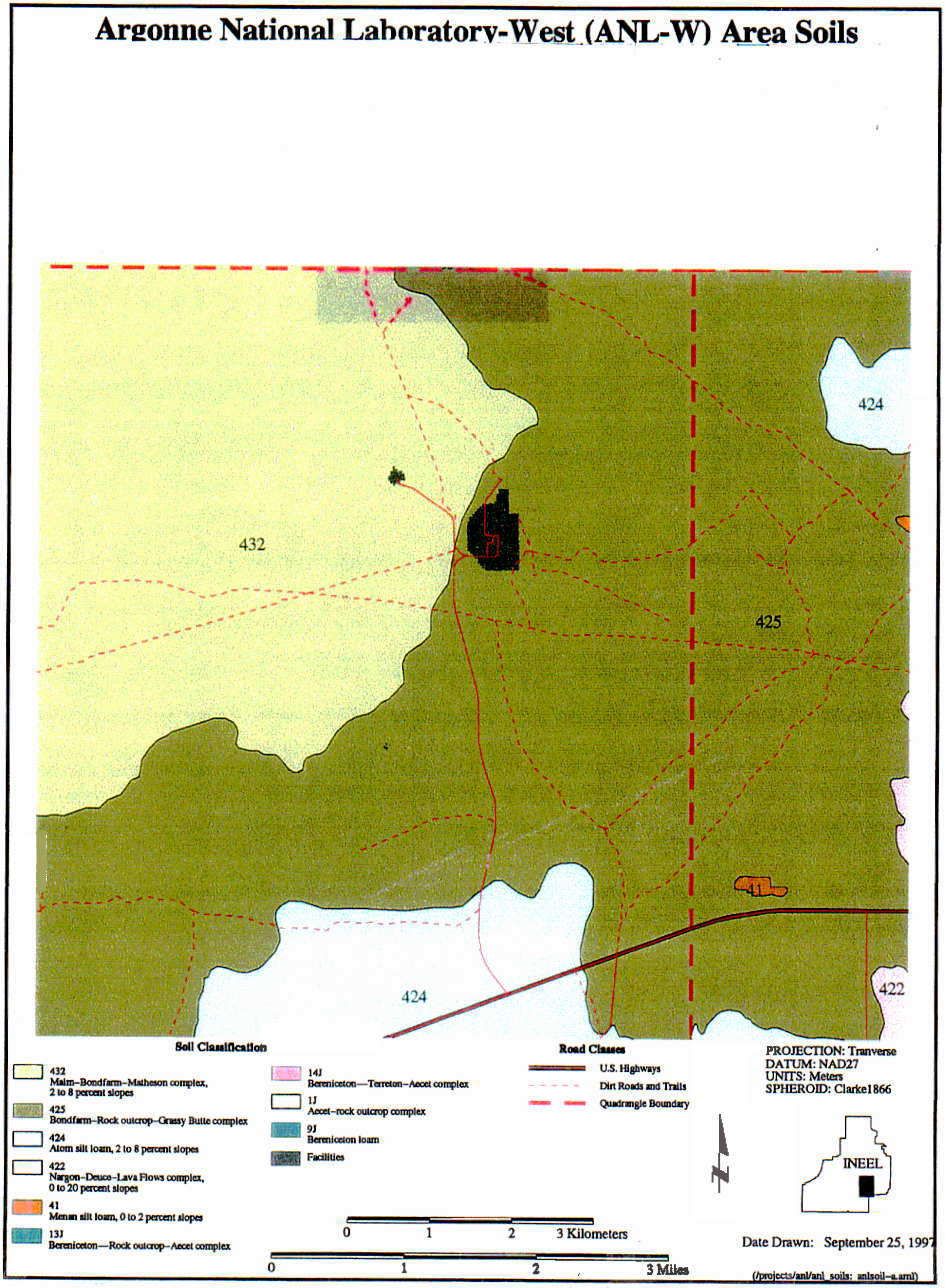

Figure 2-4 General Soil Types in the Vicinity of ANL-W

moderately rapid. Effective rooting depth is 25 to 50 cm (10 to 20 in.). Available water capacity is low. Surface runoff is slow or medium, and the hazard of erosion is slight or moderate. The hazard of soil blowing is very slight.

Rock outcrop consists of exposed basalt rock. Crevices in the rock contain some soil material that supports a sparse stand of grasses, forbs, and shrubs.

The Grassy Butte soil is very deep and somewhat excessively drained. It formed in sandy eolian material. The underlying material to the depth of 152 cm (60 in.) or more is grayish-brown and gray loamy sand. The soil is calcareous throughout and has a layer of lime accumulation at a depth of 48 cm (19 in.). The permeability of the soil is rapid. Effective rooting depth is 152 cm (60 in.) or more, and the available water capacity is low or moderate. Surface runoff is very slow or slow. The hazard of soil blowing is very high.

2.1.3.2 Soil Agronomic Analysis

Agronomic analysis of the soils was completed for both cesium-contaminated soils and inorganically-contaminated soils. The agronomic analysis consists of general information such as electron conductance; saturated paste pH; organic matter percent; percent lime, sand, silt, and clay; texture, sodium, cation exchange capacity (CEC), base saturation, extractable calcium, magnesium, sodium, potassium, phosphorous, soluble pH, grain size, and acid/base potential. Table 2-2, shows the agronomic analysis results for cesium-contaminated and inorganically-contaminated soils.

2.1.3.3 Soil-Contaminant Concentrations

For the ANL-W sites that are undergoing remediation, the contaminants and concentrations vary for each site. Table 2-3 summarizes the site, contaminant, and the contaminant remediation goal. As required by the EPA, the contaminant concentration for each site was determined by calculating the 90% Upper Confidence Limit (90% UCL) of the mean. Since the 90% UCL is a calculated statistic, the final result varies greatly with the outliers in a data set. If the data does not contain outliers, the 90% UCL value is only slightly above the mean. However, if outliers are encountered, the 90% UCL concentration increases significantly over the mean. Phytoremediation is anticipated to extract a larger percentage of contaminants at areas with higher concentrations while still removing contaminants at lower concentrations. Thus, after phytoremediation is completed, the overall effect is that the 90% UCL will meet the remediation goal because the resultant mean concentration should decrease slightly and the outlier concentrations should be significantly decreased.

2.1.3.4 Surface Water

Recharge to the Snake River Plain Aquifer (SRPA) in the vicinity of ANL-W occurs as snow melt or rain. During rapid snow melt in the spring, moderate recharge to the aquifer can occur. However, high evapotranspiration rates during the summer and early fall prevents significant infiltration from rainfall during this period. Because of the distance from the surrounding mountains and permanent surface-water features (i.e., the Big Lost River), the SRPA beneath ANL-W is unaffected by underflow or recharge from these sources.

Table 2-2 Agronomic Soil Sample Analysis

Analysis	Units	Interceptor Canal Mound (cesium-contaminated soil)	Main Cooling Tower Blowdown Ditch (inorganic-contaminated soil)
Electron Conductance	mmho/cm	1.76	0.88
pH	pH units	7.41	8.57
Percent Organic Matter	%	2.35	1.59
Lime	%	15.3	5.41
Sand	%	45	47
Silt	%	42.1	34.6
Clay	%	12.9	18.4
Texture	N/A	Loam	Loam
Na Cation Exchange Capacity	mg/kg	2500	TBD
Cation Exchange Capacity	meq/100 g	10.9	TBD
Base Saturation Cation Exchange Capacity (CEC)	% CEC	2.84	112
Extractable Calcium	mg/kg	5200	5310
Extractable Magnesium	mg/kg	360	510
Extractable Sodium	mg/kg	20	76
Extractable Potassium	mg/kg	430	438
Extractable Phosphate	mg/kg	30	48
Soluble Sulfate	mg/kg	26	71
Soluble Calcium	mg/kg	270	N/A
Soluble Magnesium	mg/kg	39	N/A
Soluble Sodium	mg/kg	11	76

mmho/cm milli mho per centimeter

meq/100g milliequivalence per 100 grams

N/A Not Applicable

Table 2-3 Final Remediation Goals for the WAG 9 Sites to be Remediated.

Receptor	Site	Contaminant	95% UCL Concentration[1]	RG* Concentration[1]
Human Health	Interceptor Canal-Mound (ANL-09)	Cesium-137	30.53	23.3
Human Health	Industrial Waste Pond (ANL-01)	Cesium-137	29.2	23.3
Ecological	Industrial Waste Pond (ANL-01)	Chromium III	1,030	500
Ecological	Industrial Waste Pond (ANL-01)	Mercury	2.62	0.74
Ecological	Industrial Waste Pond (ANL-01)	Selenium	8.41	3.4
Ecological	Industrial Waste Pond (ANL-01)	Zinc	5,012	2,200
Ecological	Ditch A (ANL-01)	Mercury	3.94	0.74
Ecological	Open portion of Ditch B (ANL-01)	Chromium III	1,306	500
Ecological	Open portion of Ditch B (ANL-01)	Zinc	3,020	2,200
Ecological	Main Cooling Tower Blowdown Ditch (ANL-01A)	Chromium III	709	500
Ecological	Main Cooling Tower Blowdown Ditch (ANL-01A)	Mercury	8.83	0.74
Ecological	Sewage Lagoons (ANL-04)	Mercury	3.2	0.74
Ecological	Industrial Lift Station Discharge Ditch (ANL-35)	Silver	352	112

[1] - Concentrations in mg/kg or pCi/g

* - Backward calculated risk-based concentration at the 1E+04 level for humans and ten times background for ecological receptors.

No permanent, natural, surface water features exist near the ANL-W site. The existing surface-water features (e.g., drainage ditches and discharge ponds) were constructed for the collection of intermittent surface runoff at ANL-W. A natural drainage channel has been altered to discharge to the Industrial Waste Pond via the Interceptor Canal. Under unusual conditions when the air temperature has been warm enough to cause snow-melt, but the ground has remained frozen, precluding infiltration, surface runoff along this channel has discharged to the Industrial Waste Pond. This condition most recently occurred during the spring of 1995. During this time, flow was visible from the surrounding basin into the Industrial Waste Pond for approximately four days. However, at no time did any water discharge from the pond to the downstream channel. Before 1995, the most recent occurrence of this situation was in 1976.

2.1.3.5 Groundwater

Estimates show nearly 2×10^9 acre-feet of water exist in the SRPA with water usage within the boundaries of the INEEL being approximately 5.6×10^3 acre-feet per year. From 1979 to 1994, the ANL-W withdrew an average of 138 million gallons of water per year from the SRPA. Principal uses of the water are for plant cooling water operations, boiler water, and potable water.

Regional flow in the SRPA is from northeast to southwest. Depth to the SRPA near the ANL-W facility is approximately 640 ft BLS, based on 1995 water-level measurements. Transmissivities of the

SRPA range from 29,000 to 556,000 ft^2 per day, based on aquifer test data from two production wells at ANL-W.

3 BENCH-SCALE PHYTOREMEDIATION RESULTS

Phytoremediation is a new and innovative technology that shows a lot of potential as a remedial tool for removal of soil contaminants. To date, however, the effectiveness of phytoremediation has been mixed at best. So prior to selection of phytoremediation for the ANL-W sites to be remediated, bench-scale testing was completed to determine its effectiveness for the contaminants present. Soil testing was performed by Argonne National Laboratory-East (ANL-E) researchers who are well recognized as experts in phytoremediation. Soils from ANL-W were collected and shipped to ANL-E for analysis and phytoremediation. The soils were dried, mixed, and placed in pots and staged at the ANL-E greenhouse prior to planting. The environmental conditions in the greenhouse were controlled to simulate the actual conditions at ANL-W. The exception to this was the addition of additional water at levels above the approximate 10 in. of annual precipitation. The bench-scale testing consisted of testing on cesium-contaminated and inorganically-contaminated soils. The results of each bench-scale test are included in Sections 3.1 and 3.2 of this document. A complete phytoremediation report on the bench-scale testing of cesium-137 and inorganics can be supplied upon request.

3.1 Bench-scale Cesium-137 Results

Bench-scale testing of the radioactively-contaminated soil was completed using three separate experiments. The first was a leachate test to see what extractants would best mobilize the contaminants. The second was a test to determine how well the plants could uptake the contaminants if they were in a soluble form. The final test was to use the plants to determine actual contaminant uptake rates from ANL-W soils by the roots and the above-ground plant matter. Summaries of each test are provided below.

The soil leaching tests removed only small amounts of radioactive cesium. The chemical extractants yielded approximately 4% increase when using 0.5 molar potassium nitrate. Yields for ammonium nitrate and urea were even lower, and removed only 2% of the cesium available. Further leaching tests are being conducted to optimize the extractant concentration.

Results of the cesium uptake of plants grown in the sand show that the plants can remove the cesium when it is in a soluble form. Results indicated that each of the plants will remove the cesium. The willow will accumulate more in the root than either koshia or canola; while koshia and canola will accumulate or translocate more cesium in the above-ground tops of the plants than the willow. The total removal of cesium is about the same for koshia and canola in the sand experiment.

The soil experiment was conducted on soils submitted to the ANL-E greenhouse that were collected from the Interceptor Canal-Mound site. These soils had an average cesium concentration of 9.9 pCi/g, which is below the established cleanup level of 23 pCi/g. It is also evident that the cesium is not readily mobilized from the clays in the soil. The soil data showed little difference in uptake from treated and nontreated soils. Koshia had the best removal of cesium with approximately 4% per year, followed by willow and canola with approximately 2-3% removal per year. It is anticipated that the koshia would be able to meet the cleanup goal of 23 pCi/g after 4-7 years, depending on efficiencies of removals in the field assuming first-order-kinetics. Koshia has the advantage in that it does not have any natural enemies and would not require installation of ecological restraints.

3.2 Bench-Scale Inorganic Results

The soil used in the inorganic bench-scale testing for inorganics was collected from the Main Cooling Tower Blowdown Ditch, which contained the highest levels of inorganics. Three separate tests were conducted during the inorganic testing. The first was a leaching test of extractants; the second, an experiment to see how well the plants can extract the contamiants from spiked sand; and finally, an actual test on ANL-W soils. The soils from the Main Cooling Tower Blowdown Ditch did not contain mercury and silver, so the actual uptakes on ANL-W for these contaminants could not be made. However, the data for the inorganics show similarities between the plants maximum uptake rates as determine in the sand experiment and the actual uptake rates in the ANL-W soils. ANL-W used uptake rates for inorganics based on similarities in the sand experiment to determine the projected mercury and silver uptake rates for ANL-W soils. The findings of each are summarized below.

The leaching tests were conducted using two known nonhazardous extractants and a control of deionized water. The extractants were citric acid and EDTA. The EDTA solution increased the zinc mobilization to 58% and chromium mobilization to 16%. The citric acid did not mobilize more than the deionized water, which had 6% mobilization.

During the sand experiment the best recovery levels for zinc, chromium, mercury, and silver were found in the willow with 96, 38, 42, and 24% recovery, respectively. The zinc was found in the roots and tops while the chromium, mercury, and silver was almost exclusively found in the roots. This shows that the willow can effectively remove the inorganics when they are available to the roots.

During the bench-scale testing of ANL-W soils, the removals were much lower than in the sand experiment. The zinc and chromium was 4-5 and 2%, respectively. Willow roots had better removal of inorganics than either koshia or canola. Mercury and silver were not detected in the ANL-W soils and thus their actual removals by the plants could not be determined. However, as stated previously, ANL-W has assumed similar removals rates based on comparison of maximum and actual uptake rates. Thus, for the mercury and silver the 2% uptake rate was used in calculations in Section 3.3. It is anticipated that with optimized use of the extractants the removals will be increased.

3.3 Years Needed to Meet Remediation Goals

Based on the best uptake removal rates of the plant species evaluated in the bench-scale phytoremediation testing, ANL-W has calculated the number of years that phytoremediation would be required to meet the remediation goals. These estimated years of phytoremediation used first-order kinetics, straight-line removal rates to calculate the number of years phytoremediation would be required. The first-order kinetic equation assumes that the removals will be constant each year with no reduction in removal rates as the concentrations decrease. The number of years required for phytoremediation to meet the remediation goals for the ANL-W sites is shown in Table 3-1. This table also identifies the uptake rates for the various contaminants and also whether remedial action is being driven by risks to human- or ecological-receptors.

3.4 ANL-W Remedial Selection

As previously stated in the WAG 9-04 ROD, the use of phytoremediation at ANL-W is contingent on successful bench-scale testing on the ANL-W contaminants. If the bench-scale testing is not successful at removing the contaminants, the contingent remedy of excavation with on-INEEL disposal could be utilized to remediate the sites. The main criteria for selection of phytoremediation for ANL-W was to remediate the sites within a reasonable period of time. ANL-W used seven years as a reasonable time period for phytoremediation and calculated the cost estimates in the ROD. A strict comparison of the costs associated with phytoremediation (2.8 million) to excavation and disposal (5.8 million) would indicate that phytoremediation could be utilized for 14.5 years for similar costs. However, a simple comparison between costs should not be made since excavation and disposal will guarantee that the remediation goals are met and phytoremediation cannot. So, DOE has assumed a 30% uncertainty with the 14.5 years which would result in 10-year time frame on the low end and 19 years on the high end. So for the determination on which alternative to use, DOE used the 10-year time frame for phytoremediation.

In addition to simply calculating which sites can be remediated within the 10 year time frame, DOE also evaluated the statistical analysis of the previous sampling. The analysis of the data consisted of a review of the previous sampling to determine if the sites contained localized outlier that would affect the calculation of the 95% UCL values. If this were the case the nonhomogenity of the soils will aid in the success of the phytoremediation. The preparations associated with the planting will homogenize the sample concentrations along the sites by reducing the outlier concentrations and making a more normally distributed data set and drastically reduce the number of years needed for phytoremediaiton to meet the remediation goals. In these cases DOE will make the decision on continued use of phytoremediation during the two year field test even if the site shows that it would take longer than the 10 years to remediate the site. Table 3-2 shows that two sites, ANL-01 Ditch A and ANL-35 would undergo phytoremediation during the two year field test to determine if these assumptions are correct..

Table 3-1 Estimated Number of Years Needed to Meet Remediation Goals.

Receptor	Site	Contaminant	Plant Uptake Percent	Years Needed For Phytoremediation Only
Ecological	Ditch A (ANL-01)	Mercury	2	82
Ecological	Open portion of Ditch B (ANL-01)	Chromium III	2	47
Ecological	Open portion of Ditch B (ANL-01)	Zinc	4.5	7
Human Health	Industrial Waste Pond (ANL-01)	Cesium-137	4.5	5
Ecological	Industrial Waste Pond (ANL-01)	Chromium III	2	36
Ecological	Industrial Waste Pond (ANL-01)	Mercury	2	63
Ecological	Industrial Waste Pond (ANL-01)	Selenium	4.5	20
Ecological	Industrial Waste Pond (ANL-01)	Zinc	4.5	28
Ecological	Main Cooling Tower Blowdown Ditch (ANL-01A)	Chromium III	2	17
Ecological	Main Cooling Tower Blowdown Ditch (ANL-01A)	Mercury	2	122
Ecological	Sewage Lagoons (ANL-04)	Mercury	2	72
Human Health	Interceptor Canal-Mound (ANL-09)	Cesium-137	4.5	6
Ecological	Industrial Lift Station Discharge Ditch (ANL-35)	Silver	2	56

The uptake results of the bench-scale tests for cesium-137 and the five inorganics in the ANL-W soils were used to determine the number of years of phytoremediation necessary remediate the sites. Table 3-1 shows the estimated years to remediate the sites using phytoremediation. As shown in Table 3-1, the chromium remediation at the east portion of the Main Cooling Tower Blowdown Ditch and Ditch B would require more than 10 years to meet the remediation goals. These two areas will be remediated using the contingent remedy of excavation with on-INEEL disposal. The pending location of the on-INEEL disposal site will be formally documented in the ESD. Table 3-2 shows summaries of which WAG 9 sites will continue with phytoremediation and which sites will undergo excavation and on-INEEL disposal.

The soils in the east portion of the Main Cooling Tower Blowdown Ditch and Ditch B do not contain any DOE-added radionuclides. Thus, DOE is proposing that these soils be disposed of at the CFA Landfill Complex as a conditional waste upon completion and approval of INEEL site-contractor Technical Procedure 713, *Radioactive Contamination Added Determination,* by DOE. In other words, the radioactive contaminant levels in these soils are at or below background and do not justify taking up space at the RWMC. The inorganics in these two sites only pose unacceptable risks to the ecological receptors exposed to the contaminants in the surface and do not pose human health risks. The CFA Landfill Complex is a RCRA Subtitle D landfill that has down gradient monitoring and sufficient cover material to prevent the ecological receptor risk. DOE will submit copies of the necessary site-contractor documentation, along with standard operating procedures used by the landfill, and the final closure documents to EPA and IDHW for review and concurance prior to implemenation of the contingent remedy. The implementation of the contingent remedy along with the final selection of the landfill will be formally documented in an ESD.

Table 3-2 Cleanup Remedy to be Utilized.

Receptor	Site	Remedy Selection
Ecological	Ditch A (ANL-01)[1]	Phytoremediation
Ecological	Open portion of Ditch B (ANL-01)	Excavation and Disposal
Human Health and Ecological	Industrial Waste Pond (ANL-01)[2]	Phytoremediation starting in 2003, pending results of the 2-year field test at other WAG 9 sites
Ecological	Main Cooling Tower Blowdown Ditch (ANL-01A)[3]	Phytoremediation in West Ditch, Excavation and Disposal for soils in the East Ditch
Ecological	Sewage Lagoons (ANL-04)[4]	Final decision pending resampling after 2033
Human Health	Interceptor Canal-Mound (ANL-09)	Phytoremediation
Ecological	Industrial Lift Station Discharge Ditch (ANL-35)[1]	Phytoremediation

1 - As discussed in Section 3.4, these sites will use phytoremediation during the two year field test. A decision on the continued use of phytoremediation will be made after review field test results.

2 - The Industrial Waste Pond remediation will not begin until after the final discharges have been received. It is estimated that Industrial Waste Pond discharges from the SPF action will be completed in 2003.

3 - The east portion of the Main Cooling Tower Blowdown Ditch will be excavated and disposed at an on-INEEL Landfill. The soils in this area contain the highest concentration of chromium and mercury would take too long to phytoremediate.

4 -.The Sewage Lagoons will stay operational until their useful life is completed. DOE anticipates that they will remain active until 2033, at which time they will need to be resampled and the risks recalculated using the latest human health and ecological

data available. If the site still poses unacceptable risks, it will be remediated.

4 ANL-01 (DITCH A)

This section discusses information specific to release site ANL-01 Ditch A and the work that will be performed during remediation. The necessary work has been subdivided into major tasks associated with preplanting, planting, irrigation, harvesting, and postharvesting activities specific to ANL-01 Ditch A. Generic activities that are common to all sites being remediated at ANL-W (such as the Health and Safety Plan and the Quality Assurance Project Plan) can be found in the appendices. The plan map and other figures for Ditch A are quite large and are included in Appendix A.

4.1 History of Site

The location of Ditch A with respect to ANL-W is shown in Figure 1-3. Ditch A conveyed industrial wastewater from the EBR-II Power Plant auxiliary cooling tower to the Industrial Waste Pond. To date, Ditch A is still being used to transport storm-water runoff, as well as intermittent auxiliary cooling tower waters. Discharges to Ditch A flow into the Main Cooling Tower Blowdown Ditch and ultimately into the Industrial Waste Pond. The mercury contamination is most likely the result of slight concentrations in the acid used to regenerate the ion beds in the EBR-II Power Plant.

4.2 Contaminants

Mercury is a contaminant of concern (COC) for ecological receptors (Functional Group AV132, Sora) only and was detected in 74% (27/38) of the samples analyzed in Ditch A. All of the mercury detections exceeded the upper limit of the 95% UCL background concentration (0.074 mg/kg). The source of the mercury is most likely from mercuric chloride used as a wood preservative in the cooling tower or from a neutron absorber in the power plant which is being decommissioned. The maximum detected concentration of 4.1 mg/kg was detected at location #10W in the surface sample (0 to 6 in.); while the UCL concentration for mercury in Ditch A was 3.94 mg/kg. In all but one instance, the surface samples at each location contained the highest concentrations of mercury with the exception of #26E. The mercury contamination in Ditch A is spread through the entire length, with the highest concentrations near the intersection of the Main Cooling Tower Blowdown Ditch and Ditch A. The mercury concentrations also decrease with increasing depth, with the highest concentrations in the surface samples (0 to 6 in.). Therefore, the maximum extent of contamination is the dimensions of both the eastern and western parts of Ditch A (5 ft wide and 400 ft long) and the vertical extent contained to the surface soils (0 to 6 in.).

4.3 Remediation Goal

The established remediation goal for the Ditch A mercury contamination is identified in the WAG 9 ROD as 0.74 mg/kg, which is calculated at 10 times the INEEL background concentration for mercury.

4.4 Preplanting Activities

Preplanting activities will occur once prior to the initial growing season at Ditch A. Pre-planting activities will involve grubbing of currently existing vegetation, grading, removing rock, installing irrigation lines, and installation of fences and signs. Each of the activities specific to Ditch A are discussed below in further detail.

4.4.1 Grubbing Activities

Ditch A currently contains relatively few weeds growing in the west end of the ditch. These weeds will be manually pulled by Plant Services Laborers and placed in a dumpster for disposal.

4.4.2 Grading Activities

Ditch A is currently used as surface water disposal and periodic blowdown from EBR-II auxiliary cooling water discharges. The ditch currently contains rebar with aluminum caps that identify the 1994 sampling locations. A metal detector will be used to find the 1994 sample locations if they are covered up with sediment. A global positioning system will be used to permanently identify these past sample locations. A small front-end loader will be used to regrade the side slopes so they will be sloped where applicable at approximately a three-for-one foot grade to allow for equipment access. Appendix A contains the typical cross-sectional view of Ditch A after grading. This grading will allow the use of farm equipment during phytoremediation.

4.4.3 Rock Removal

Any rock that is bigger than a cobble (2-3 in.) will be removed manually using a steel rake prior to planting. These rocks are not native to this area and have been used as ground cover over open areas. Over time the rocks have been dislodged and are now located in the ditch bottom. The rocks will have no contamination on their outer surfaces and will be placed on the outer edges of the ditch banks (still within the contaminated zone).

4.4.4 Irrigation-Line Installation

Ditch A will require additional water to fully optimize the removal efficiencies of the willow. To accomplish this, ANL-W will install a supplemental irrigation system to water Ditch A. The irrigation system has been designed to allow for automatic watering with a manual override to either stop or start watering. The system will use untreated groundwater in the ANL-W fire suppression system as the water source and have all distribution lines originating in a centralized location near the ANL-W Cooling Tower. A schematic of the distribution system is shown in Appendix A. The plan map of Ditch A shows the location of and specifications for the irrigation system for Ditch A. The distribution lines will be located on the top of the south and west ditch banks. This will allow for minimal wind drift losses from the typical southwesterly winds. The irrigation heads will be commercially available home sprinkler lines and be fully adjustable from 0-180 degrees with a range out to 15 feet. The heads will be placed on risers with nelson 30-lb pressure regulators to keep water rates consistent between each irrigation head. Each head will be spaced 15 ft apart to allow for double coverage with each head. The irrigation line will be commercially-available 2-inch poly line. The irrigation line will be slightly trenched into the ditch bank to minimize rotational movement and reduce the tripping hazard.

4.4.5 Barrier Installation

The Ditch A site is located inside the ANL-W boundary, which has a double security fence around the outside. Additional fencing around this site is not necessary to prevent human intruders. Signs will be placed on fences around Ditch A that identify the area as a CERCLA site that is undergoing phytoremediation and identify a point of contact. The signs will be placed approximately every 50 ft along the ditch banks. The signs (constructed of stenciled plastic) will face out from the Ditch A.

4.5 Planting Activities

This site will be planted with 3-, 4-, and 5-ft tall bare-root willow plants in a grid pattern as shown in Appendix A. The bare-root willow will be spaced approximately 18 in. on center to optimize the biomass of the plant at the end of the field season. The holes for the trees will either be made manually using a spade or hydraulically driven auger mounted on a boom. The holes will be excavated to approximately 12 inches into the soil to allow for complete planing of the willow roots. The soils will be placed back into the hole and lightly tampped. Water will be added to allow for settling of soil around the roots and to reduce the amount of void space. A second worker will remove a willow plant from the shipping box and place it into the hole, taking care not to damage the roots. The willow will be aligned vertically and the soil from the bottom of the ditch will be placed around the root, lightly compacted, with water added to remove the void spaces. This procedure will be repeated until all willows have been planted in accordance with the plan map (shown in Appendix A). Where the tractor can not reach a planting location, a willow tree will be manually planted using a shovel to dig the hole.

If subsurface rock is encountered, the hole location of the hole can be moved toward the center of the ditch. The center of the ditch contains the contamination; keeping the plants closest to the ditch center maximizes the potential for contaminant removal. It is important to try to complete the planting as close as possible to the design grid pattern to limit the potential for stunting plant growth, which will reduce the biomass produced and ultimately the contaminant removal.

If basalt is encountered before the planting depth of 14 in. is reached, the plant can still be planted as long as the soil is at least 6 in. deep. If the soil is less than 6 in. deep, the next grid location will be planted.

4.6 Irrigation and Ammendments

To optimize the biomass of the willow plants growing in Ditch A, supplemental irrigation will be installed to keep the soil moisture content in the optimum growing range. The optimum moisture content is roughly estimated to be between 40-50 % based on discussions from representatives with the United States Department of Agriculture (USDA). Calibration of the moisture detectors along with the moisture content set point adjustments will be made in the field with the ANL-W soils. The system can be adjusted to optimize the moisture content needed by the plants to the actual site being remediated. To accomplish this, moisture detectors will be installed that will automatically turn on or shut off the irrigation when the soil moisture varies outside these levels. Two moisture detectors will be stacked vertically at depths of 1.0 and 1.5 ft. The automatic watering switch will be installed on the detector located at the 1.0 ft depth. This will "train" the willow plant roots to stay within the contaminated zone as they seek out the water. The lower moisture detector will be used to show that irrigation has not leached the contaminants below the contaminated zone.

The zonal-type irrigation distribution system that will be employed at ANL-W is shown in Appendix A. The system will allow each of the remedial sites at ANL-W to operate individually, based on it's individual water needs. The system can be manually overridden if it is determined that more or less water is required for an individual site. As shown in the distribution system figure in Appendix A, a pressure reducer and chemical injection system have been installed prior to the individual manifold distribution lines. This will allow ANL-W to add soil ammendments [such as fertilizers and or extractants (EDTA and/or citric acid)] to each of the waste sites through the irrigation system. Nutrient analysis of the soils will be tested periodically and the necessary fertilizers will be applied to meet the needs of the plants through their growing season. The chemical injection system will only be operated after the root zone fully covers the contaminated area and then only in manual mode.

4.7 Harvesting Activities

Harvesting of the willows will be accomplished by first reducing the moisture of the soil to less than 30%. The moisture detectors and cables will be manually removed from the soil. The irrigation system will then be manually operated and run for approximately 5 minutes. (This will wet the area and act as a dust suppressant while harvesting activities are being conducted.)

Harvesting of the willows in Ditch A will be accomplished using a front-end loader mounted on a small tractor. A hydraulically-controlled implement will be installed on the front-end loader. The tractor will drive down the ditch; and as the trunks of the trees get wedged into the attachment, the loader can be raised to remove the tree root from the ground. Once the root is removed from the soil, the operator will then use the hydraulic ram to cut the willow trunk into two pieces. Another worker will take the two portions of the plant and feed them into the wood chipper. The discharge chute of the wood chipper will be directed into a compactable (4 x 4 x 6 ft) box. When the box is full, an empty box will replace the full box; and the full box will be moved to a staging area for labeling and radiological surveying, and then staged in a cargo container to await shipment to the WERF facility in accordance with the Reusable Property and Recyclable Materials Waste Acceptance Criteria (RRWAC) Section 4.3.2. This process will continue until all willow plants have been removed from the soil.

DOE is still evaluating the potential to cube the willow chips and use the cubed wood product as an alternative energy source. The INEEL currently has a Process Fuel Program that is currently burning paper, cardboard, magazines, scraps from a wood chipper, styrofoam and plastic wrap as a supplemental fuel in a coal-fired boiler. The use of the cubed willow product will be site specific and depend upon approval of the INEEL site contractor and analytical results of the cubed willow product. If acceptable for incineration, the dry willow has approximately 9,500 BTU's per pound.

4.8 Postharvesting Activities

After all willow plants in Ditch A have been harvested, postharvesting activities will be initiated, which includes regrading the soils back to the typical preplanting cross-sectional requirements shown in Appendix A. The irrigation line will be turned off at the fire hydrant and the distribution line pressurized to 50 psi using a portable Sulair compressor. Each of the distribution lines will be manually activated to blow the water from the irrigation line. This will be completed for each distribution line to prevent water from breaking lines during the winter.

4.9 Waste Disposal Activities

The boxes of chipped wood are prepackaged during the chipping work performed after harvest of the trees and staged in a cargo container at ANL-W. The boxes of chipped wood will be surveyed, labeled, and appropriate documentation completed in accordance with Low-Level Waste Section 4.5 of the RRWAC. When the operating site contractor submits written approval to ANL-W, the filled cargo containers of waste will be shipped to the WERF facility. The WERF facility will in accordance with their procedures incinerate, sample, and disposing off-gas filters and ash waste in accordance with their approved standard operating procedures.